PROPULSION DIRECTORATE

Monthly Accomplishment Report
December 2000

Contents ***Page***

IHPRPT PHASE I SOLID BOOST DEMONSTRATOR A SUCCESS!: On 16 November 2000 the culmination of an aggressive 23-month Integrated High Payoff Rocket Propulsion Technology (IHPRPT) Program, funded jointly by AFRL's Propulsion Directorate and Thiokol Corp, resulted in a highly successful full-scale rocket motor demonstration. The purpose of the test was to demonstrate new technologies in the case, propellant, nozzle, and control technologies in a 92-inch diameter, 120,000 pound class rocket motor. The test was carried out at Thiokol's facilities in Utah. Preliminary quick look data indicated that all the goals of the program were met or exceeded. The technologies that were demonstrated have the potential to yield a 23 percent increase in payload capability at a 32 percent lower cost for solid booster space lift applications. The demonstrated technologies are now ready to be transitioned into small and large launch vehicles as stages or strap-on boosters, and defense missiles. This IHPRPT Program demonstration is the first in a series of tests that are part of a three-phase, government and industry coordinated effort that began in 1996 with the vision of doubling rocket propulsion capability by 2010. IHPRPT has been cited as a model of government and industry partnership in research and development. (Capt K. Parent, AFRL/PRSB, (661) 275-5750)

The IHPRPT Phase I Solid Boost Demonstrator was successfully fired on 16 November 2000

AIAA HONORS EDWARDS' "ROCKET SITE": The "Rocket Site" at Edwards AFB, California, formally known as the Air Force Research Laboratory Edwards Research Site, was recently honored by the American Institute of Aeronautics and Astronautics (AIAA) when it was named as one of the institute's historic aerospace sites. Sheila Widnall, former secretary of the Air Force and current AIAA president, and Brig Gen Paul D. Nielsen, AFRL Commander, unveiled a bronze plaque mounted in front of a large rocket nozzle to officially dedicate the site for its significant contributions to the nation's aerospace program. Inscribed on the plaque are the words:

> *"Rocket Site - Leading the vision and evolution of the Air Force rocket propulsion technology from its earliest days. The Rocket Site's men and women and their unique research, development and test facilities have provided the discoveries,*

developments, and applications of scientific and engineering answers to national defense rocket propulsion needs for more than 50 years."

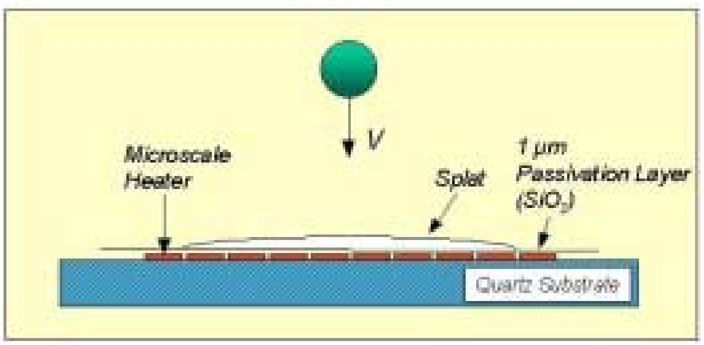
In addition to the Edwards site, AIAA chose four other locations as historic aerospace sites: the Dutch Flats Airport in San Diego where Charles Lindbergh first flew the Spirit of St. Louis; Aunt Effie's Farm near Auburn, Massachusetts, where Dr. Robert Goddard successfully launched the first liquid propellant rocket in 1926; the original Aerojet Engineering Company manufacturing facility in Pasadena, California; and Tranquility Base, located on the moon. Of all the sites being honored by AIAA, the Rocket Site is the only one still active at its original location. The site, located on the northeast corner of Edwards AFB, covers 65 square miles. Two-thirds of the nation's high-thrust static rocket test stands are located there along with unique space altitude and propulsion research facilities. (R. Adams, AFRL/PROI, (661) 275-5465)

Want more information?

- An expanded story on this honor can be read at the Air Force Link website at http://www.af.mil/news/Nov2000/n20001124_1757.shtml.

The medallion commemorating the "Rocket Site" as a historic aerospace site

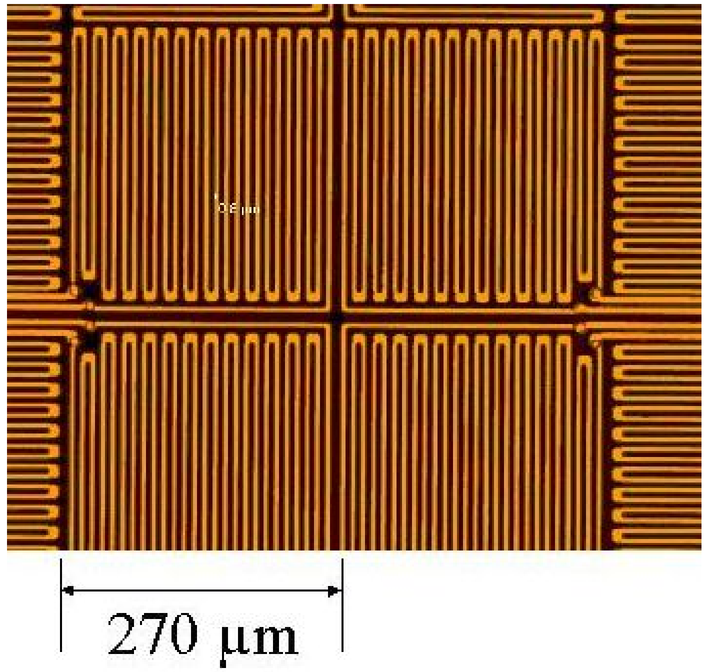
Testing being performed at Edwards' "Rocket Site"



Schematic of droplet impingement on microscale heater

<u>NOVEL MICROSCALE HEATER FOR DROPLET HEAT TRANSFER STUDIES</u>: Under a research grant from the Propulsion Directorate's Power Generation & Thermal Management Branch (AFRL/PRPG), the University of Maryland has successfully developed and demonstrated a novel, microscale heater array concept to help understand droplet heat transfer mechanisms. The use of liquid droplets to cool heated surfaces is an important process in several industrial and defense applications. For example, high heat transfer rates coupled with good temperature uniformity can be achieved with spray cooling. Spray cooling could be used to remove large amounts of energy from electronic devices while keeping the device temperature gradients small and junction temperatures below 85°C. The background literature on this work to date has largely been empirical and lacking predictive capability. The goal of the current work is to examine the fundamental behavior of the transient heat transfer characteristics of dynamically impacting droplets. The experimental heater array developed under this program consists of 96 independently controlled heaters (each 270 μm x 270 μm in size) arranged in a square. Each heater in the array is held at constant temperature using a bank of electronic feedback loops, and the power required to do this for each heater is measured. This technique allows time and space resolved heat transfer distribution to be measured in unprecedented detail. Measurements to date

have shown that the traditional analytical models used to predict droplet heat transfer have serious deficiencies in the early stages of droplet evaporation. Planned additional work will include characterization of heat transfer distribution for a real spray nozzle under varying free-stream conditions. The results of this work will allow spray-cooling mechanisms to be understood in more detail and could lead to better, more efficient means of cooling high-power electronics. Along with AFRL, the National Security Agency's Laboratory for Physical Sciences and NASA Glenn Research Center have co-sponsored various phases of this work. (R. Ponnappan, AFRL/PRPG, (937) 255-2922)



Platinum heater array

SHEEHY HONORED FOR SCIENTIFIC/ ENGINEERING EXCELLENCE: Dr. Jeffrey Sheehy recently won the 1999 Edwards AFB Civilian Excellence Award for Scientific/Engineering Excellence. Dr. Sheehy is the Chief of the Propulsion Directorate's Propellants Branch (AFRL/PRSP) at Edwards AFB, California. His branch is tasked with planning, formulating, and directing fundamental research, exploratory, and advanced development of new propellants and propellant technology for application to military space and missile systems. The branch also investigates advanced propulsion concepts such as dense plasma focus, laser propulsion, fusion propulsion, and anti-matter propulsion. In addition, Dr. Sheehy leads the High Energy Density Matter (HEDM) team, which has been an AFOSR Star Team since 1990. This group is devoted to finding and producing new high-powered rocket propellants or additives that exceed current capabilities for use in future Air Force systems. This award specifically recognized Dr. Sheehy's computational efforts to develop an all nitrogen compound. Such a compound may allow future advances in high-energy rocket propellants or explosives. (J. Sheehy, AFRL/PRSP, (661) 275-5762)

Dr. Jeffrey Sheehy

COLD FLOW FUEL SYSTEM SIMULATOR NOW OPERATIONAL: In November 2000, the U-2 Cold Flow Fuel System Simulator was activated at AFRL's Propulsion Directorate. Located in Fuels Branch (AFRL/PRTG) facilities at Wright-Patterson AFB, Ohio, the simulator will be used in research to develop a cold flow variant of JP-8+100. The simulator, which includes actual U-2 fuel system components, is being baselined on JPTS (TS for *thermally stable*) and JP-8+100. The performance of JP-8+100 and JPTS in the simulator will define the required performance improvement. Once the simulator has been baselined, experiments with the low temperature additives will be performed. Motivation for this effort stems primarily from a desire to replace JPTS, the fuel used for the high-altitude U-2 reconnaissance plane, with the more economical JP-8. Depending on current market conditions, the cost of JPTS can be as much as 3 to 4 times the cost of JP-8. It is estimated that the replacement fuel, dubbed JP-8+100 LT (LT for *low temperature*), will save the Air Force an estimated $8.2 million per year in fuel costs. In addition, the availability of JP-8+100 LT will permit U-2 operations from any air base supporting JP-8 fuel. Testing has commenced in the new Cold Flow Fuel System Simulator and is anticipated to continue thorough 2003. (C. Obringer, AFRL/PRTG, (937) 255-6390)

Various components of the U-2 Cold Flow Fuel System Simulator

SOLAR THERMAL PROPULSION TESTING UNDERWAY: A demonstration test in support of Integrated High Payoff Rocket Propulsion Technology (IHPRPT) Solar Thermal Propulsion (STP) efforts got underway at Edwards AFB in November 2000. This testing involves personnel from the Propulsion Directorate as well as Thiokol Corp and SRS Technologies. This test, designated IHPRPT Demo IT-5 (Integrated Test 5), is a vacuum deployment test of the 4 by 6 meter off-axis Flight Scale Concentrator 1 (FSC-1). The goal of this test is to verify deployment of a solar concentrator system in a vacuum lower than 10^{-4} torr. The test approach is to deploy the concentrator system from a packaged state similar to that used in a flight experiment. Successful deployment of the concentrator systems is essential to the operation of a solar thermal propulsion system. Solar thermal propulsion is a concept in which the sun's energy is used to propel a spacecraft. A solar thermal rocket collects energy from the sun and uses it to heat stored hydrogen to high temperature. The heated hydrogen is expelled through a nozzle to produce low thrust (about 1 lb_f for 7 by 10 m concentrator pair) at a very high efficiency (specific impulse of 700 to 1,000 seconds). Compared to current methods, STP systems will be capable of placing greater payload mass into useful geosynchronous orbit. (M. Holmes, AFRL/PRSS, (661) 275-5615)


A conceptual solar thermal propulsion system

VARIABLE DISPLACEMENT PUMP FOR FIGHTER ENGINES: On 2 November 2000, a new task order contract was awarded to the Chandler Evans Control Systems Group (CECO) of BF Goodrich Aerospace to continue development of its Variable Displacement Vane Pump (VDVP) technology. This contract is an add-on to an earlier task order which is to design and test a VDVP as a primary fuel pump for the KC-135R aircraft's F108 engine. The basis of CECO's vane pump technology is that the pump cavity outer case is cam-operated to adjust so that fuel displacement flow is matched to the engine's immediate flow demand. This minimizes fuel return and the associated additional waste heat returned to the fuel tanks. This concept differs from typical fuel pumps now in use, which are sized for maximum flow (e.g., takeoff) conditions. The add-on has two primary goals. One goal is to revise the F108-based pump after initial tests to help it achieve preliminary flight readiness (PFR) status, which will help this pump become a candidate for commercial technology transfer into


KC-135R Stratotanker refuels an F-22 Raptor

commercial airliner fuel systems. The second goal is for CECO to design a new high-pressure, high-flow version of the VDVP to match the fuel flow requirements expected for the main engine of the Joint Strike Fighter (JSF). One of the propulsion engine candidates for the JSF is General Electric Aircraft Engines' F120 engine, and this engine's fuel system performance needs will serve as the basis for the high-pressure, high-flow VDVP design. Given that a tactical aircraft can possibly be limited in waste heat addition to its fuel tankage during a mission's return flight, the VDVP provision of minimizing the fuel return and waste heat can be very beneficial to JSF fuel system thermal management. (E. Durkin, AFRL/PRPG, (937) 255-6241)

STELTZ NAMED FEW SUPERVISOR OF THE YEAR: The Miami Valley Chapter of Federally Employed Women (FEW) recently recognized the Propulsion Directorate's Sharon Steltz as Supervisor of the Year. Mrs. Steltz was chosen as top supervisor in Category II (GS-12 and 13s). Selection criteria for this annual award include efforts to support and mentor women in the federal workplace, supervisory capabilities, and community involvement. Nominees for the award are drawn from all the federal employers in the Miami Valley, and the nominees can be military or civilian, male or female. Mrs. Steltz currently serves as the Chief of the Propulsion Directorate's Business Services Branch (AFRL/PROB) at Wright-Patterson AFB, Ohio. She has been a federal employee for 28 years and has worked primarily in the field of financial management. For the past two years, she has been a valuable member of the laboratory team. She was presented with this award at the Miami Valley Chapter of FEW's annual awards luncheon held at the Wright-Patterson AFB Officers' Club on 1 November 2000. (S. Steltz, AFRL/PROB, (937) 255-1889)


Mrs. Sharon Steltz

IN-SITU CARBON-CARBON DENSIFICATION PROCESS LICENSED: A process for fabricating high quality carbon-carbon developed by the Propulsion Directorate's Propulsion Materials Applications Branch (AFRL/PRSM) recently took a large step toward commercialization. SAF/GAQ approved an exclusive license for this process, known as the "In-Situ Densification Process," to SMJ Carbon. This approval completes commercial transfer of the "In-Situ Densification Process" to SMJ Carbon and opens the door for corporate and other external investment into the company. The in-situ densification process is a liquid phase route to producing high-quality, machinable, carbon-carbon composites. Because the carbon matrix precursor is a liquid, the process takes only a fraction of the time required by traditional Chemical Vapor Infiltration (CVI) at a fraction of the cost. It is estimated that this carbon-carbon production process is 10 times faster and one-fifth the cost of current processes. Markets for this technology reside mainly in the aerospace community, and parts manufactured using the process include rocket nozzles, aircraft brakes, and fasteners. The process also enables carbon-carbon weapon system components which were previously impossible to create (e.g., Peacekeeper post-boost control system). With further cost reductions, materials manufactured by this process may find substantial markets in consumer products such as sporting goods. (K. Chaffee, AFRL/PRSM, (661) 275-6170)

Parts fabricated using the In-Situ Densification Process

<u>GORD CAPTURES PRESTIGIOUS AWARD</u>: The Propulsion Directorate's Dr. James R. Gord has been selected for the Outstanding Engineers and Scientists Award. The Affiliate Societies Council of the Engineering and Science Foundation of Dayton sponsors this prestigious award, which is presented each year to several of the top engineers or scientists in the Dayton, Ohio, area. Dr. Gord is a senior research scientist in the Propulsion Directorate's Combustion Science Branch (AFRL/PRTS), and he is a renowned expert in laser diagnostics and their application to combustion research. The 2001 awards ceremony will be held on Thursday, 22 February 2001 at Sinclair Community College. This is well-deserved recognition for Dr. Gord, who is a key member of the Propulsion Directorate team. (R. Hancock, AFRL/PRTS, (937) 255-7487)

Dr. James R. Gord

<u>VISITING SCHOLAR ASSISTS PLASMA-ETCHING RESEARCH</u>: Mr. Peter Fendel, a visiting scholar from Germany's University of Essen, has joined the Propulsion Directorate's in-house plasma research team (AFRL/PRPS) to start work on laser spectroscopic measurements of plasma electric fields. The International Education Program office at the Ohio State University is sponsoring Mr. Fendel's visit. Mr. Fendel's master's thesis was on laser-induced fluorescence measurement radicals in a radio frequency excited plasma-etching tool. His work at the Power Division is closely tied with parallel work being performed at the University of Essen, and this should lead to further collaboration with the group led by Prof Frieder Dobele of the University of Essen's Physics Department. (B. Ganguly, AFRL/PRPS, (937) 255-2923)

<u>PEARCE RECEIVES ASTM AWARD</u>: The contributions of the Propulsion Directorate's Patricia Pearce were recognized during the American Society for Testing and Materials (ASTM) biannual meeting in December 2000. At the meeting, Mrs. Pearce (*in absentia*) was presented the Committee D02 Award of Appreciation. ASTM's Committee D02 on Petroleum Products and Lubricants presents this award for outstanding achievements in this technical area. This award recognized Mrs. Pearce's outstanding efforts as the secretary of the J01 Committee on Turbine Fuel Specifications. She was also recognized for her contributions in coordinating civil and military fuels standards, acting as the military standards coordinator, and her work on the water separation task force. Mrs. Pearce currently serves in the Propulsion Directorate's Fuels Branch (AFRL/PRTG) and is responsible for fuel specifications, managing PRTG's 6.3 program, and serving as a member of numerous international committees within organizations such as NATO and ASCC. The award was presented during the J01 Committee meeting on 7 December 2000 in Nashville, Tennessee. (W. Harrison, AFRL/PRTG, (937) 255-6601)


Mrs. Patricia Pearce